MARCH 31, 1981

MINIMUM FLOW REQUIREMENTS OF THE SOUTH SASKATCHEWAN RIVER DOWNSTREAM OF GARDINER DAM

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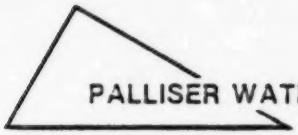
FOREWORD

In 1963, the South Saskatchewan River Development Commission's report "Minimum Streamflow Requirements Downstream from the South Saskatchewan Dam" recommended that the minimum mean daily flow at Saskatoon should be 1500 cfs (42.5 m^3/s). Subsequently, this flow was adopted as a firm requirement in the operation of Lake Diefenbaker. In 1979, another study and report entitled "Overview of Water Related Concerns in the Lower Saskatchewan Basin" concluded that the 1963 study should be updated with emphasis given to determining the current validity of the 1500 cfs (42.5 m^3/s) figure. Accordingly, in 1980, Saskatchewan Environment hired the firm of Palliser Water Resource Consultants Ltd. to conduct an independent study. That study is the subject of this report.

The study involved a detailed review of the minimum flow criterion for the South Saskatchewan River downstream of Gardiner Dam. It considered, among other things, the following factors: consumptive water uses, water intakes, water quality, recreation, navigation, river crossings, hydro-electric power generation and river regime. In carrying out this assignment, the consultant met with numerous parties including officials of Meewasin Valley Authority, Saskatchewan Power Corporation, ferry operators, provincial departments, municipalities and others.

The study concluded there is no pressing need for a significant change in the minimum mean daily flow criterion but it recommended a slight increase to 45.5 m^3/s. No clear basis for this increase of 3.0 m^3/s was established.

As recommended in the aforementioned overview study, this updated report is made available to interested individuals and agencies. While the report is clearly supportive of a minimum flow of about 42.5 m^3/s, Saskatchewan Environment is not necessarily in complete agreement with all of the statements made by the consultant or the manner in which they are expressed. It must be emphasized, however, that this comment in no way detracts from the overall findings and conclusions of the report.



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by

Wm. M. Berry, P. Eng.
Regina, Saskatchewan

March 31, 1981

SUMMARY

The flow of the South Saskatchewan River downstream of Gardiner Dam is controlled by the operation of Lake Diefenbaker Reservoir. Throughout the period of operation of the reservoir, minimum releases from Gardiner Dam have been established to give an average daily flow of 42.5 m^3/s in the river at Saskatoon.

A review of past and present experiences of water users affected by low river flows has revealed that there is no pressing need to make a significant change in present operating procedures. Most water users have done a creditable job in adapting to the new flow patterns--which are so much different from those which occurred before the dam was constructed.

However, because the river flow has only fallen to the designated minimum on so few occasions in the past (see Figure 9), there is little reason not to raise it somewhat. A nominal increase in the designated minimum flow to 45.5 m^3/s is recommended. This would aid, to a small extent, ferry operators and some of those pumping water from the river who have faced very difficult operating conditions when river flows become extremely low. The recommended increase would have an adverse but inconsiderable effect on SPC's operations.

CONTENTS

		Page
SUMMARY		
CHAPTER 1:	INTRODUCTION	1
CHAPTER 2:	RESERVOIR CONSIDERATIONS	
	Power Production	3
	Irrigation	4
	Recreation	5
	Flood Control	5
	Other Considerations	5
CHAPTER 3:	DOWNSTREAM INTERESTS AND CONCERNS	
	Consumptive Uses	7
	Water Intake Problems	7
	Ferries	9
	Water Quality	10
	Recreation	10
	Fish and Blackflies	11
CHAPTER 4:	DISCUSSION	
	Consumptive Uses Affecting the Reservoir	12
	Water Levels of the Reservoir	14
	Downstream Consumptive Uses	15
	Downstream Low Flows	16
	Downstream Water Levels and Flow	17
	Downstream Water Levels - Daily Variations	17
	Limitations on Uniform Reservoir Outflow	18
	Sand-bars and Blackflies	19
	Safety Aspects	19
	The Pollution/Dilution Problem	19
CHAPTER 5:	CONCLUSIONS AND RECOMMENDATION	
	Conclusions	21
	Recommendation	22
	Effect of Recommendation	22

CONTENTS (cont.)

LIST OF FIGURES

		Page
Fig. 1:	Historical Use of Water - South Sask. River at Alberta-Saskatchewan Boundary	12
Fig. 2:	Lake Diefenbaker - Recent Water Level Fluctuations	14
Fig. 3:	Growth of Irrigation from South Saskatchewan River between Gardiner Dam and the Forks	facing 15
Fig. 4:	Average Monthly Flow - South Saskatchewan River at Saskatoon	facing 16
Fig. 5:	How Water Levels Vary with Discharge - South Saskatchewan River at Saskatoon	facing 17
Fig. 6:	Average Daily Flows in 1977 - South Saskatchewan River at Saskatoon	facing 21
Fig. 7:	Water Level Fluctuations of South Saskatchewan River above Saskatoon Weir in 1980	@ back
Fig. 8:	Inflow to, Outflow from, and Water Levels of Lake Diefenbaker	@ back
Fig. 9:	Complete Record of Low Flows of South Saskatchewan River at Saskatoon during 12-year Period 1969-1980	@ back

INTRODUCTION

This study and report has been prepared in accordance with the terms of a Saskatchewan Environment's contract dated October 22, 1980. The terms of reference for the work include:

> "The purpose of the proposed study is to review the minimum flow criterion for the South Saskatchewan River downstream of Gardiner Dam and recommend and provide rationale for the recommended criteria."

The operation of Lake Diefenbaker, and the rate of water releases therefrom, is under the control of the Saskatchewan Department of the Environment. The Department is guided in this matter by advice from the South Saskatchewan Reservoir Board. This Board was initially established under the 1958 Federal-Provincial Agreement on the South Saskatchewan River Project, which reads in part:

> "Upon transfer of the reservoir to Saskatchewan under Clause 7 (1), there shall be constituted a board of Officials, to be called the "South Saskatchewan Reservoir Board", consisting of four members, two of whom shall be appointed by Canada and two of whom shall be appointed by Saskatchewan, the duties of which shall be to maintain effective liaison and co-ordination of maintenance and operation of the reservoir."

Ever since the dam went into operation, reservoir operating guidelines have been followed which aim to provide maximum overall benefits to all concerned. This procedure generally has resulted in the storage of a large part of the summer runoff and release of the stored water during the following winter. In this regard, the operators have attempted to make summer releases relatively small yet adequate to provide for the needs of downstream users.

The present guidelines followed by the Reservoir Board provide that minimum releases of water from Gardiner Dam should not cause the average daily flow of the river through Saskatoon to fall below 42.5 m^3/s.

Chapter 2 sets out the situation of those water users affected by the water levels of Lake Diefenbaker, as its water level is largely determined by the amount and timing of releases through Gardiner Dam. The situation of those water users located downstream of the dam is covered in Chapter 3. Chapter 4 discusses various aspects of the matter,

including possible future problems and trends. Conclusions and a recommendation for change is set out in Chapter 5.

CHAPTER 2

RESERVOIR CONSIDERATIONS

Lake Diefenbaker has the capacity to store and regulate a large portion of the annual flow of the South Saskatchewan River, and thus provide benefits in terms of irrigation, power production, recreation, flood control and downstream flow regulation. Generally, annual water level changes in the reservoir vary from a low elevation in the month of March to an elevation some ten meters higher in the month of September. These changes affect all reservoir users.

The amount and timing of releases of water from Lake Diefenbaker directly affects the water levels of the lake. Correspondingly, the amount of water coming into, and drawn from, the lake determines the amount available for downstream releases.

Power Production

Saskatchewan Power Corporation (SPC), the operator of Coteau Creek Hydro Electric Station at Gardiner Dam, considers this station to be a key element in their province-wide generating system. The plant started commercial production in December, 1968 with three units totalling 187,500 kva, and having a potential annual energy output of 800,000,000 kwh.

SPC has, therefore, a major interest in water-level fluctuations of Lake Diefenbaker and in releases of water from Gardiner Dam. With regard to lake levels, the higher the level the more power can be produced at the turbines. For example, at any flow, approximately 10% more power can be produced whenever the water level of the lake is raised by five meters.

With regard to minimum releases during summer, the SPC position is that -

(1) the average daily flow should not be less than 42.5 m^3/s--as any lesser flow would create serious condenser-water cooling problems at the Queen Elizabeth and A. L. Cole thermal plants in Saskatoon,

(2) low flows during the summer should be released intermittently during the day so that the generating units can utilize the flows efficiently and the power can be produced to serve the system's peak daily demands. It is estimated that, in the summer, power produced during peak demand periods in any day is worth twice the value of power produced during non-peak periods,

(3) In years of below-average runoff, the average daily flow should generally not be more than 42.5 m^3/s as a greater flow would decrease the amount of water stored in the reservoir for use during the following winter. SPC has established that water used for power generation at Gardiner Dam during the winter:

(a) is about twice as valuable as that released to serve summer peaks, because it then serves to satisfy the system's annual peak demands, and

(b) is also worth additional increments of value because of its re-use at the downstream Squaw Rapids Hydro Electric Station, and its potential re-use at the proposed Nipawin and other future downstream sites.

Irrigation

Water from Lake Diefenbaker is being used to irrigate a number of farms.

Individual farmers are establishing small irrigation projects with water pumped from the lake up to their fields. It is estimated that at the present time about 2,800 ha are being privately irrigated in this fashion. More is being planned.

The South Saskatchewan River Irrigation Project (S.S.R.I.P.) is located on the east side of the river in the Outlook area. Water is pumped directly from Diefenbaker Lake up into a canal leading to their irrigated lands. Presently about 16,000 ha are being served by this system.

The cost of pumping irrigation water up from the lake varies with the reservoir level. The higher the level of the lake, the lower the pumping costs become. In the case of the S.S.R.I.P. for example, a five meter rise in lake levels reduces their pumping energy requirements by about 25%.

Thus, irrigationists have an interest in seeing high summer reservoir levels, which could be achieved by lessening the rate of outflow from Gardiner Dam during the summer.

Recreation

The use of Lake Diefenbaker and its shorelands for both water-based and on-shore activities has proved to be very popular. Much of this activity is centred around the use of the lake by visitors to the fairly recently established provincial and regional parks.* The uses to which the lake is put include swimming, power boating, water skiing, canoeing, sailing and fishing.

To a large extent, these activities depend on the maintenance, during the summer, of fairly stable lake levels preferably at a high elevation. Thus, those concerned with these matters would want summer releases from Lake Diefenbaker set at such rates as would achieve the above objective.

Flood Control

The large storage capacity of Lake Diefenbaker has the potential to significantly reduce the size of floods along the South Saskatchewan River downstream of Gardiner Dam. If the reservoir level is kept low, more of the incoming floods can be stored, resulting in lower flood peaks downstream. If summer releases are kept low, the reservoir level rises faster and reduces its effectiveness in controlling floods.

Other Considerations

Water level fluctuations of Lake Diefenbaker, as influenced by

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* Douglas Prov. Park - near the Qu'appelle Dam
Saskatchewan Landing Prov. Park - north of Swift Current
Palliser Regional Park
Herbert Ferry Regional Park
Eston Riverside Regional Park

the release of water downstream of the dam, also affect:

(a) the operation of various other water intake works, such as those of the Town of Elbow and some campsite operations,

(b) the operation of the Riverhurst Ferry which crosses the lake,

(c) the character of sedimentation and delta formation occurring at the western end of the lake,

(d) the character of shoreline erosion, slumping and beaching which is occurring all around the shore of the lake, and

(e) the continuing but decreasing increments of deep-seated foundation spreading underneath Gardiner Dam. It has been noted that the rate of change of foundation movement is related to the rate of change in reservoir level.

CHAPTER 3

DOWNSTREAM INTERESTS AND CONCERNS

The downstream users who are dependent on summer releases of water from Gardiner Dam have various interests of differing character, including water quantity, water quality, river surface elevations, river morphology, aquatic life, recreation and aesthetics.

This chapter sets out the interests and concerns in these matters--it does not attempt to answer them. The questions raised are dealt with in Chapter 4.

Consumptive Uses

The amount of water being withdrawn from the South Saskatchewan River system is increasing. Upstream of Lake Diefenbaker, in Alberta, irrigation districts are increasing the size of their developments and planning for still greater expansion. In Saskatchewan, the water demand from the reservoir is growing in that irrigationists are pumping increasing amounts of water, diversion into the Qu'Appelle River continues, and there has been public discussion on the possibility of effecting new large diversion schemes into the southern parts of the province primarily for municipal and industrial use.

Downstream of the reservoir, municipal, industrial and irrigation use is rising, with the increase forecasted to continue.

Some users are concerned with the possibility that so much water will be taken from the river that critical shortages will occur in the future.

Water Intake Problems

Downstream of the dam all water used consumptively is obtained by pumping directly from the river. The river bed is composed of sandy material which moves and shifts position from time to time. This makes the problem of siting and maintaining pump intakes extremely difficult and frustrating. The pumping intake problem is not new. Prior to construction of the dam, water levels in the river fluctuated sharply and the movement of sand and sand bars was erratic. Problems with pump intakes were severe.

Today the situation is not much better. In part because of the somewhat more stable water levels in the river due to flow regulation by the dam, supplemented by a good forecasting service to warn of impending floods, increasing numbers of farmers are starting to irrigate directly from the river. On the other hand, the established minimum flow of 42.5 m^3/s causes very low water levels in the river. On occasion, a number of operators experience difficulty in maintaining the required supply of water through their intake works because of low water and sand-bar movement.

SPC's Queen Elizabeth and A. L. Cole thermal Power Stations at Saskatoon depend on their river intake works to provide cooling water for their operation. They have experienced few problems with river flows in recent years, but their problems would become severe at any flow below 42.5 m^3/s because of the higher natural temperature of the river water at such low flows.

The City of Saskatoon has few problems with their water intake works.

The Town of Outlook pumps water directly from the river to serve their municipal needs. River intake problems have been a continuing source of worry for the last 50 years. At the present time it is reported that a floating type of intake, used in the summer, has solved this problem to a great extent. Shifting sand bars at this location are a continuing problem.

The intake for PFRA's Demonstration Farm is situated just upstream of Outlook's intake. Problems with the same sand bars have been so severe that sometimes dredging operations have had to be done by PFRA in order to maintain a supply of water to the intake.

The Village of St. Louis pumps water indirectly from the river by a system of well-points located in the river's sandbeds. A shifting river channel and low river water levels affect this system, lowering its yield, but an equal concern lies with sand coming into the system through the well screens and damaging their pumps. During the summer of 1980 it became necessary to locate a portable pump adjacent to the main channel of the river and deliver (untreated) water directly into their water supply system.

The Saskatchewan Water Supply Board takes water directly from the river at a point just a few miles south of Saskatoon to serve customers on both sides of the river. This scheme provides water to Vanscoy, two potash mines, two golf clubs and numerous individuals. The Board's staff have experienced difficulty in maintaining a sufficient supply of water to their pumphouse when the river flow drops to 42.5 m^3/s, primarily due to shifting river sands, although to date no shortages have occurred. It is projected that their demand for water may double (to a peaking demand of 0.25 m^3/s) in a few years due largely to expansion of the potash mines.

Water intake problems of differing types are also experienced by a few industrial users, many individual irrigators, other irrigators of a public or private commercial nature, and by Pike Lake Provincial Park. Over the past few years these operators have adapted, to a greater or lesser extent, to the established minimum flow although no doubt a somewhat greater minimum flow would be welcomed.

These users today are primarily concerned with two other factors which can severely disrupt their operations. One is the movement of sand bars which can easily seal off fixed intakes, and the other is sudden rises or falls in river levels which can force the relocation of portable pumps and intakes.

Ferries

Six ferry crossings are operated during the open-water season by the Ferry Services Branch of Saskatchewan Department of Rural Affairs. Prior to the year 1978, these ferries experienced difficult and, in some cases, impossible operating conditions whenever the flow of the river dropped to 42.5 m^3/s. In 1977 the river flows were held close to that minimum throughout the whole of the spring and summer season. Because the ferries operated that year with great difficulty, the Ferry Services Branch accelerated their program of improving the crossings by river training works. By late 1977, this program was so successful that all ferries were back in service, albeit with light loads.

Today the situation remains the same. When the flow decreases to 42.5 m^3/s, the water level drops. Although all the ferries can keep operating, their load-carrying capacity is reduced. Clarkboro and

St. Laurent ferries cannot then carry loaded grain trucks, just one or two cars. The Hague ferry and possibly others can still carry farmers' grain trucks but not semi-trailers or heavy construction equipment. The Birch Hills and Weldon ferries are not seriously affected by these low flows.

Water Quality

Between Gardiner Dam and Saskatoon the river is clear because of low turbidity, and of good quality. Downstream of Saskatoon the effluent from the city and some industrial plants have an impact on the water quality of the stream for a distance of some 50 to 80 kilometers in the summer and all the way to the Forks in the winter.

The City provides primary treatment of its municipal sewage. This includes the removal of suspended solids and chlorination only of the liquid effluent.

The question of when Saskatoon should upgrade its sewage treatment process is presently under consideration. The need for this could be related to the normal level of summer flows of the river.

Recreation

Except in Saskatoon, recreational use in the immediate river valley is minimal. Danielson and Pike Lake Provincial Parks provide for on-shore activities, primarily picnicking. On the river, some few individuals engage in boating, canoeing and fishing.

In and immediately adjacent to Saskatoon, the Meewasin Valley Authority is engaged in enhancing the scenic beauty and promoting the recreational use of the river and its valley. In the past, recreational use has been minimal but recently water-based activities (canoeing, boating and water-skiing) have grown and the indication is that the demand for such use will increase. The Authority has plans to develop walkways, bicycle paths and picnic sites adjacent to the stream, and expect to prepare suitable sites for swimming in the river immediately upstream of the City.

Thus recreational users would be interested in having greater regulation (less fluctuation) of river flows, as well as an increase in the presently established minimum flow.

Fish and Blackflies

Since Gardiner Dam was completed the downstream fish population has declined, but not because of the sometimes low minimum summer flows. Their reproductive urges are geared to rise during the usual pre-dam floods in May and June. Now, such floods do not always occur due to flow regulation, and rate of spawning is diminished. Apparently, the established minimum flow of 42.5 m^3/s is the minimum acceptable for fish habitat; any less flow would be unacceptable as river water temperatures would rise too much.

Prior to the completion of the Gardiner Dam, the river water was murky with suspended solids from far upstream. After completion, the water in the river has been relatively clear allowing sunlight to reach the stream bed and promoting the growth of aquatic plants. This growth is particularly evident downstream of Saskatoon where the city's (diluted) sewage effluent also appears to enhance aquatic growth.

Between Saskatoon and the Forks, a particularly nasty species of blackfly has now, since 1970, established itself on this reach of the river by using the new aquatic growth as nesting sites and breeding several times a year. As a result, livestock in that region has suffered and it is estimated that the consequent annual loss to farmers is very high. Even if the present established minimum flow was substantially increased, the aquatic growth would remain as would the flies.

CHAPTER 4

DISCUSSION

Previous chapters reviewed the various matters of interest and concern related to low river flows below Gardiner Dam. This chapter reviews these matters and sets out the physical aspects of the problem.

Consumptive Uses Affecting the Reservoir

Lake Diefenbaker receives all the natural flow of the South Saskatchewan River, less those amounts consumed or diverted by others upstream of the Lake. Upstream uses have been increasing, and this trend is expected to continue for some time, especially in Alberta. However, Saskatchewan is protected in this regard by the 1969 Federal-Provincial Master Agreement on Apportionment. Under this agreement, Alberta has the right to use approximately one half the natural flow of the river at the Alberta-Saskatchewan boundary. Figure 1 shows the amount of Alberta's share of the water, and the extent to which it has been used.

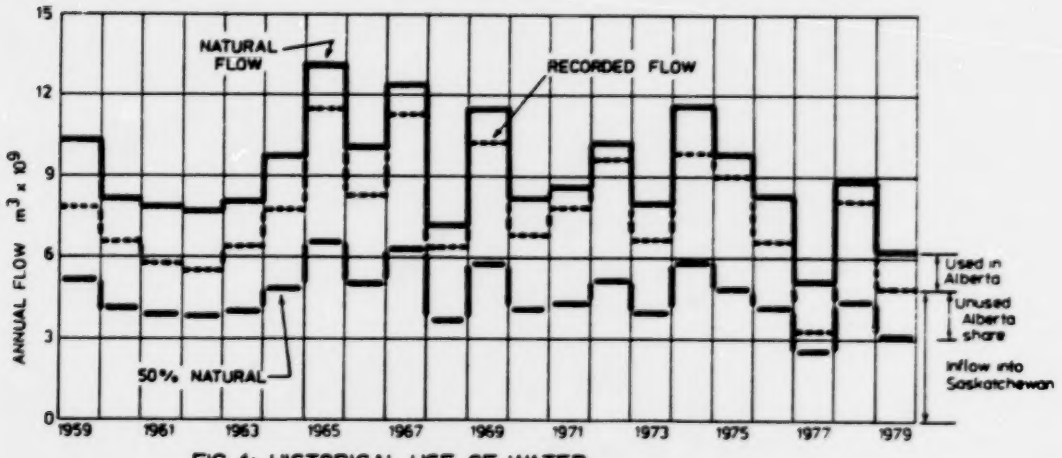

FIG. 1: HISTORICAL USE OF WATER
SOUTH SASK. RIVER AT ALBERTA-SASK. BOUNDARY

In Saskatchewan, water users upstream of the lake and those taking water directly from the lake*, together consume only 1% of the inflow in an average year, and 4% in a drought year.

In the future there is no doubt that Alberta will use more and more of its share of the waters of the South Saskatchewan River.

In southern Saskatchewan, the need for more water is rising and several schemes to divert water from Lake Diefenbaker have been proposed. In addition, an expansion of the South Saskatchewan River Irrigation Project is foreseen with a consequent rise in water use. It may not be unreasonable to suggest that the use of water directly from the lake will increase at an average rate of 4% per year over the next twenty years.

In total, it may be speculated that in the foreseeable future total water use upstream of Gardiner Dam will reduce present annual flows downstream from the dam by 20% in an average year and by 33% in a very dry year.

Some users of water in Saskatchewan may gain from such a development (see next page of this report). None would be hurt other than SPC which would have to bear the burden of reduced water supplies. The primary effect of smaller future inflows would be on the amount available for storage in Lake Diefenbaker in the summer, with a consequent reduction in the amount released during the winter for power production. Minimum summer releases would be unaffected as they are regulated by the South Saskatchewan Reservoir Board: somewhat longer periods of low summer flow could however be expected.

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* Includes South Saskatchewan River Irrigation Project, Saskatchewan Water Supply Board's S.S.E.W.S. Project, private and community irrigators, and the diversion into the Qu'Appelle Valley--does not include reservoir evaporation losses.

Water Levels of the Reservoir

Figure 2 shows the fluctuations in the level of Lake Diefenbaker in recent years. The maximum range in levels is about ten meters, required in order to store high summer inflows for later release during the winter.

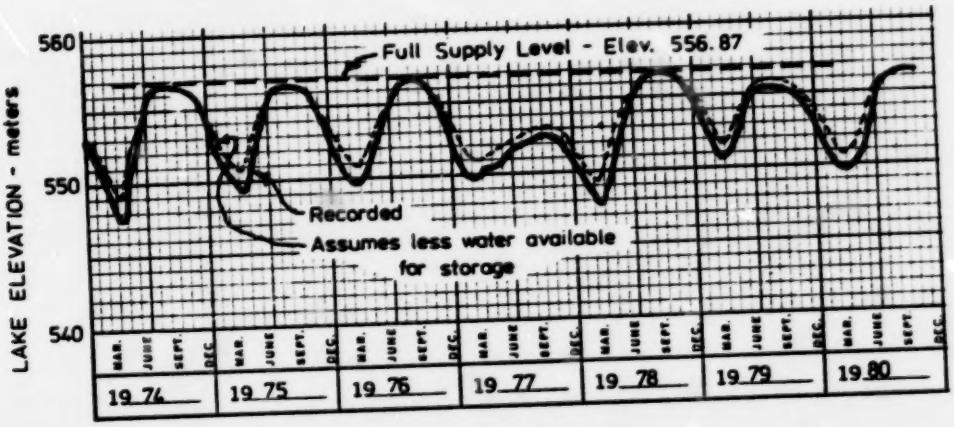

FIG. 2 - LAKE DIEFENBAKER
RECENT WATER LEVEL FLUCTUATIONS

As has been stated earlier, as more water is consumed upstream of and from the lake, less water will be available for summer storage. It can then be expected that the lake's annual fluctuations will occur at higher elevations, roughly taking the pattern shown by the dotted lines in Figure 2, in order that winter releases may take place at as high a head (total drop at the power plant) as possible to maximize power production.

As a result, this modified pattern should reduce the pumping costs of irrigationists, may benefit recreationalists, reduce the revenues of SPC and lessen the value of the reservoir for flood control. It would have little effect on minimum flows downstream of the dam.

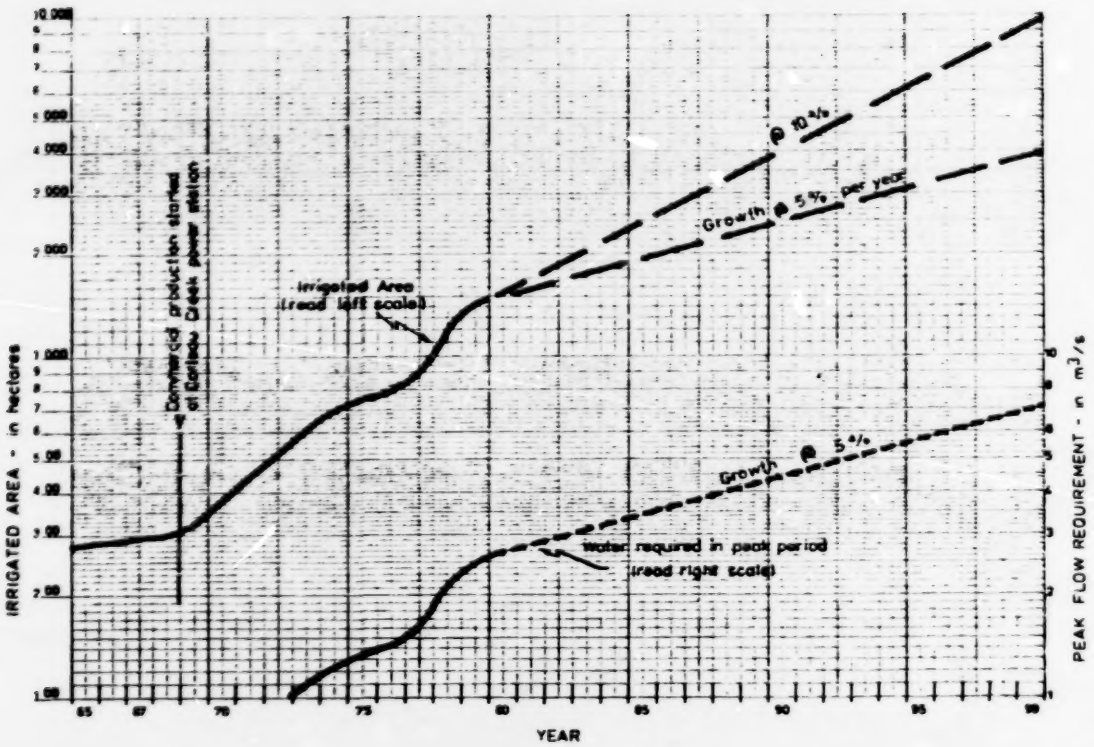

FIG. 3: GROWTH OF IRRIGATION
FROM SOUTH SASKATCHEWAN RIVER
BETWEEN GARDINER DAM AND THE FORKS

Downstream Consumptive Uses

Relatively little water is used consumptively downstream of Gardiner Dam from the South Saskatchewan River--less than 1% of the flow in an average year, and about 2% in a dry year. Roughly one-half of this is used between the dam and Saskatoon. Little is consumed by SPC's thermal power stations in Saskatoon, and the city itself returns about 90% of its water intake supply to the river in the form of effluent, plus additional amounts in the form of storm drainage runoff. Saskatchewan Water Supply Board's Saskatoon-West Project water demand is not large (an average withdrawal of 0.06 m^3/s during 1979), and the net use by industrial users is small.

Excluding natural losses, the greatest consumptive use of water by far on this reach of the river is for irrigation. Figure 3 shows the growth of irrigation in recent years by acreage, and projections of future irrigated land based on 5% and 10% annual rates of growth. The areas irrigated to date have expanded in recent years at the 10% rate, but this is believed to be too high for use in the future: a more realistic projection may be 5%. Thus the amount of land irrigated may rise from the 1,460 hectares today* to 4,000 ha in the year 2000.

Figure 3 also shows an estimate of peak withdrawals from the river by private and other irrigators. Their demand for water generally peaks in the last two weeks of June (dependent on rainfall) and it is this demand that has been plotted on the graph. Withdrawals for irrigation from the river at other times of the year are insignificant. If this irrigation use increases 5% annually, the peak June demand for water will rise from the present 2.6 m^3/s to 7 m^3/s in the year 2000.

Thus the amount of water totally consumed below Gardiner Dam is not large, neither in volume nor in rates of withdrawal. A continuation of the moderate rate of growth in such uses should not be a matter of concern. A significant increase in consumptive use would presumably be met by additional releases of water from Gardiner Dam--in this case, SPC would be able to produce essentially the same amount of power at

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* Area actually irrigated is assumed to equal the area authorized under the Water Rights Act--assumes the land not actually irrigated in any one year is offset by unlicensed areas which are irrigated.

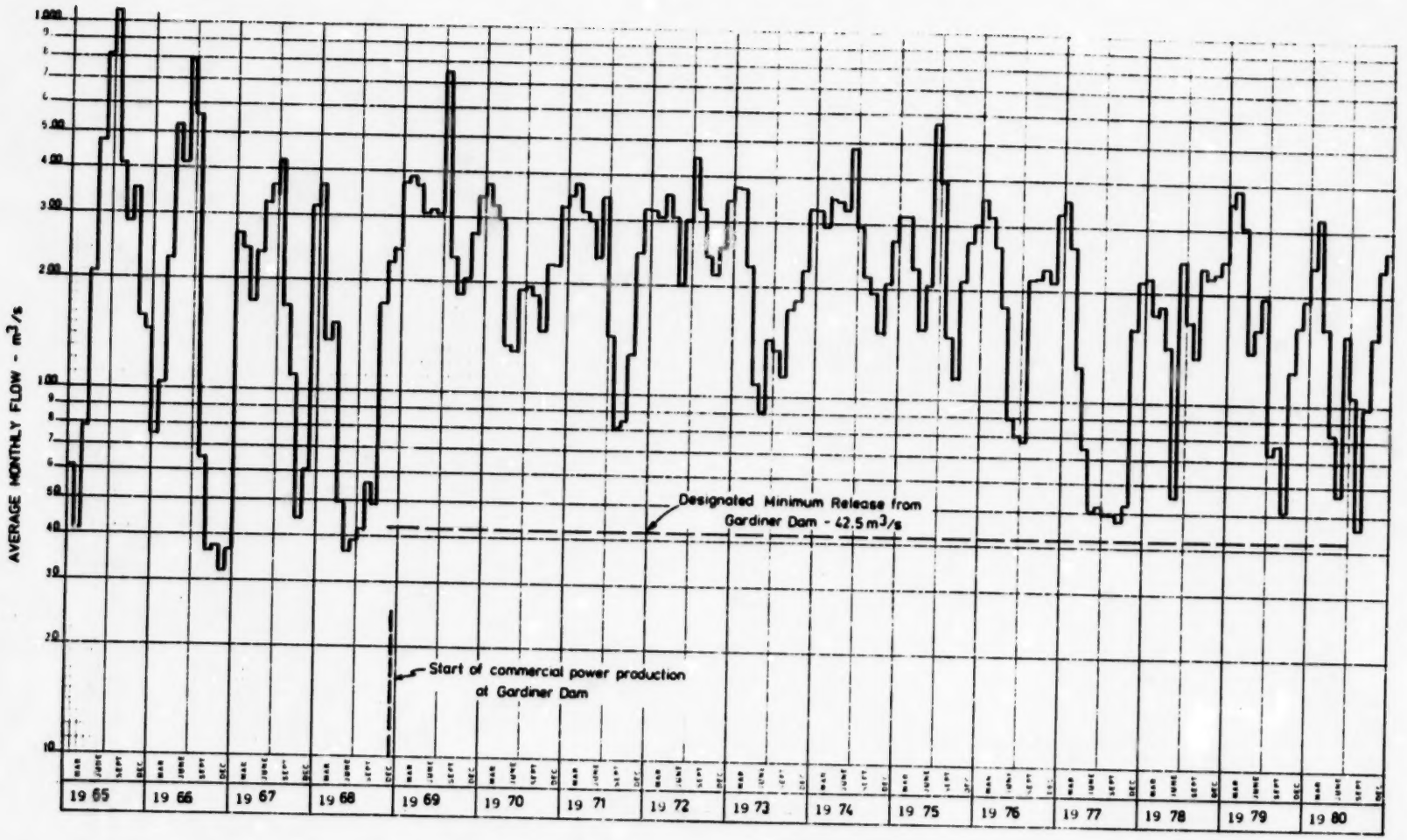

FIG. 4 : AVERAGE MONTHLY FLOW
SOUTH SASKATCHEWAN RIVER AT SASKATOON

Gardiner Dam but would lose the difference in value between winter and summer production.

Downstream Low Flows

By the end of the year 1965, the last of Gardiner Dam's diversion tunnels was plugged and the authorities then had some measure of control over the release of water through the dam. In the following three years, 1966-68, water was released on occasion at a minimum flow of 28.5 m^3/s, partly to aid in the final filling of the reservoir. Experience with these low flows downstream was so unsatisfactory that since that time 42.5 m^3/s has been adopted* as the average daily minimum release.

The history of the river flows at points downstream of the dam is shown in Figure 4. This illustrates average monthly flows at Saskatoon which is the mid-point of the areas of concern.

This figure shows that in the eight-year period (1969-76) following the start of commercial power production at the dam, average river flows remained well above the designated minimum at all times. In the last four years (1977-80), some average monthly flows have closely approached the minimum. An examination of the daily records shows that, in these low-flow months, the river did flow from time to time at or just above 42.5 m^3/s. In six days during this 12-year period the flow did fall below the designated minimum.**

It is likely that on some days when the flow at Saskatoon dropped below the designated minimum, evaporation losses and irrigation withdrawals between the dam and the city were the two main causes of the shortfall.

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* As recommended earlier in an (unpublished) report dated March, 1963 entitled "Minimum Streamflow Requirements Downstream from the South Saskatchewan Dam" by S. R. Blackwell of the then South Saskatchewan River Development Commission.

** May 13, 1977 - average daily flow was 41.6 m^3/s
May 14, 1977 - " " " " 41.6 "
May 15, 1977 - " " " " 41.1 "
Oct 11, 1977 - " " " " 41.9 "
May 15, 1978 - " " " " 40.2 "
May 22, 1978 - " " " " 41.1 "

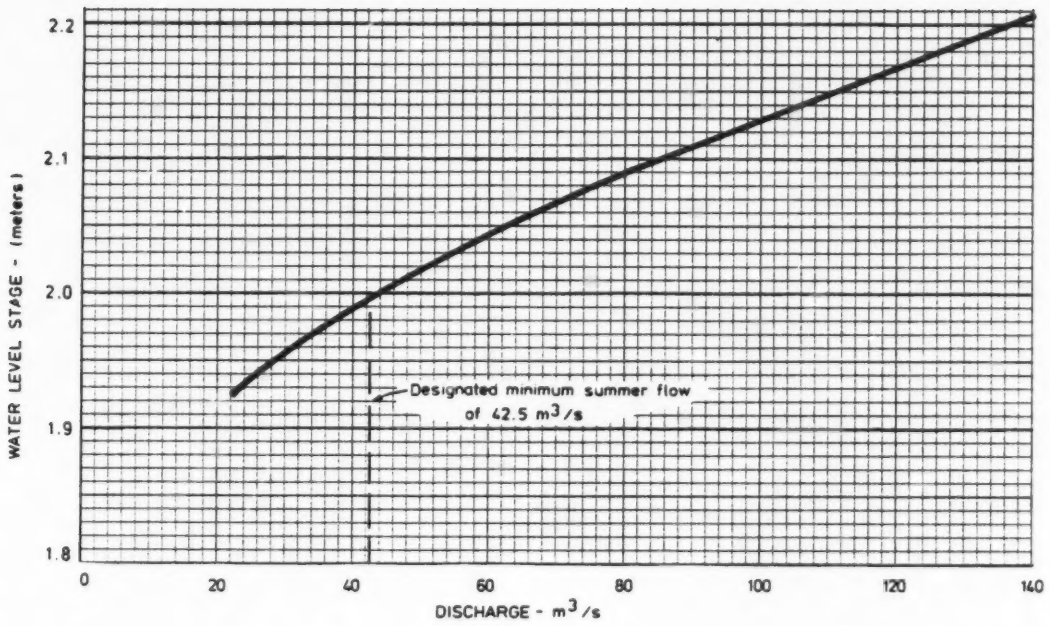

FIG.5 : SOUTH SASK. RIVER AT SASKATOON
HOW WATER LEVELS VARY WITH DISCHARGE

Downstream Water Levels and Flow

Since there is more interest in the river's water levels than the rate of flow, data was gathered to show how the one varies with the other. Figure 5 shows the stage-discharge relationship at Saskatoon upstream of the existing weir.

From this graph it can be seen that, in Saskatoon, a fairly large increase in flow is required to effect a significant rise in water level. Thus, with respect to the designated minimum summer flow of 41.5 m^3/s,

An increase of:	Would raise the water level by.
10% (to 46.7 m^3/s)	0.012 m (0.5 inches)
20% (to 51.0 ")	0.023 m (0.9 ")
50% (to 63.7 ")	0.055 m (2.2 ")

The very small rises in water level with increasing discharge rates is due to the wide expanse of the Saskatoon weir which controls the river level within the city.

A review of hydrometric data from other reaches of the river, beyond the influence of the weir, both upstream and downstream from Saskatoon, shows that changes in flow would cause about twice the change in river level shown above for Saskatoon. That is, if the minimum summer flow of 42.5 m^3/s were increased by 10%, the river level (where not controlled by the weir) would rise by 0.025 m (one inch).

It thus becomes apparent that the designated minimum flow would have to be increased by a large amount in order to achieve any appreciable rise in low river levels.

Downstream Water Levels - Daily Variations

During low-flow periods in the summer, SPC releases the required water through the turbines at high rates during the hours of high power demand, and shuts down the turbines completely during the hours of low demand. Thus, immediately below Gardiner Dam the water is released in 'slugs' which become damped out or made more smooth as the flow travels downstream. By the time the flow reaches the Forks, the daily fluctuations are hardly noticeable.

Where the river flows through Saskatoon the daily fluctuation is in the order of 0.05 - 0.12 m (2 - 4 inches) at low flows. Figure 7 (at the back of this report) is a photographic reduction of the trace of the

official water-level recording device located within the city, showing the variations for a few days in July and August of 1980.

Saskatoon's wide weir no doubt serves to lessen the fluctuations within the city. Just upstream of the city the daily variation is about twice as great, while closer to the dam it is very much greater. Immediately downstream of the city the daily variation would be somewhat less than twice as great, and becomes smaller and smaller as one travels further downstream.

These fluctuations have significance to some of those pumping from the river. When intakes are sited fairly close to the surface of the river at low flows, it is the low point of the daily fluctuation which causes difficulties.

Daily fluctuations could be smoothed by having SPC operate their Coteau power plant continuously. In this event, the power produced would have to go to serve 'base load', and thermal power stations would have to be started up and shut down daily to serve peak loads--at a considerable increase in cost.

A 10 or 20% increase in the average minimum flow would not significantly aid those between Gardiner Dam and Outlook, but the fluctuations would become greater. Downstream of Outlook, the low water level during the day would rise, but only in the order of 0.02 to 0.05 meters*.

Daily changes in water level also affect recreational activity within the Meewasin Valley Authority area. Practically all recreational use of the river and valley occurs during daylight hours. The low point in the daily river-level cycle should ideally occur in the middle of the night. Fortunately this is what does happen now in Saskatoon at the lower flows, as can be seen in Figure 7.

Limitations on Uniform Reservoir Outflow

In very dry years, such as 1977, the storage capacity of Lake Diefenbaker can capture and store all the inflow not required for downstream releases. However, in normal and in flood years the reservoir cannot store all the spring and summer inflow. During these years, as

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* Except in Saskatoon, where the rise would be about one-half as much.

can be seen in Figure 8, extra water is discharged through the power turbines and, when extra-large floods are experienced or are imminent, still more water must be released over the spillway as was done in 1975.

Thus, except in drought years, uniform summer outflow from Gardiner Dam can not be achieved. The available (live) storage in Lake Diefenbaker is too small, relative to the normal inflow, to accomplish this.

Sand-bars and Blackflies

The frustrating problem of shifting sand-bars faced by those pumping water from the river has not significantly changed since the construction of the dam. The problem will continue, as implied in the paragraph quoted on the opposite page written by an authority on the subject.

The construction of the dam did, however, make the water flowing downstream very much less turbid, allowing aquatic weeds and blackflies to flourish. Increasing the designated minimum flow would not improve the present situation in this regard.

Safety Aspects

With respect to safety on the river, the changes in flow pattern caused by the dam has:

(a) in the summer, made the river a little safer, with the result that small-boating activities are increasing and plans are even being made to develop swimming beaches! Prior to the dam, high summer flows, with its consequent turbulence, discouraged all except the foolish from engaging in such activities, and

(b) in the winter, made the river (ice) surface much more dangerous. Prior to the dam, the fairly constant low winter flows permitted, at times, fairly safe use of the ice surface. Today, with higher non-uniform flows, the ice surface can not be trusted at all for any use.

The Pollution/Dilution Problem

Studies made by Saskatchewan Environment* in the years 1976-79

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* "Report on Nutrient Impact on the South Saskatchewan River" by the Water Pollution Control Branch, Saskatchewan Environment, May 1980.

indicate that, during periods of low flow, Saskatoon's present sewage treatment plant effluent

(a) is causing significant increases in algal growth in the river for some 28 km downstream of the city, and has a significant impact on weed growth as far as 81 km below the city,

(b) directly or indirectly, causes reductions in dissolved oxygen down to critical levels for fish for some distance below the city,

(c) makes the river water downstream to Clarkboro Ferry unacceptable for any use due to high fecal and total coliform concentrations according to the provincial surface water quality objectives. At the Hague Ferry the water was found to be suitable for use after treatment, but not suitable for vegetable crop irrigation, and

(d) in the winter, under ice, fecal bacteria could survive as far downstream as the Forks.

In recent years, when the above effects became apparent, summer flows have generally been well above the designated minimum--see Figures 4 and 8. For this reason the writer believes that a nominal increase in the designated minimum flow would not serve to decrease the downstream effects of Saskatoon's effluent releases. It probably would be necessary to triple the minimum flow before any lessening of the stated downstream effects would be noticeable.

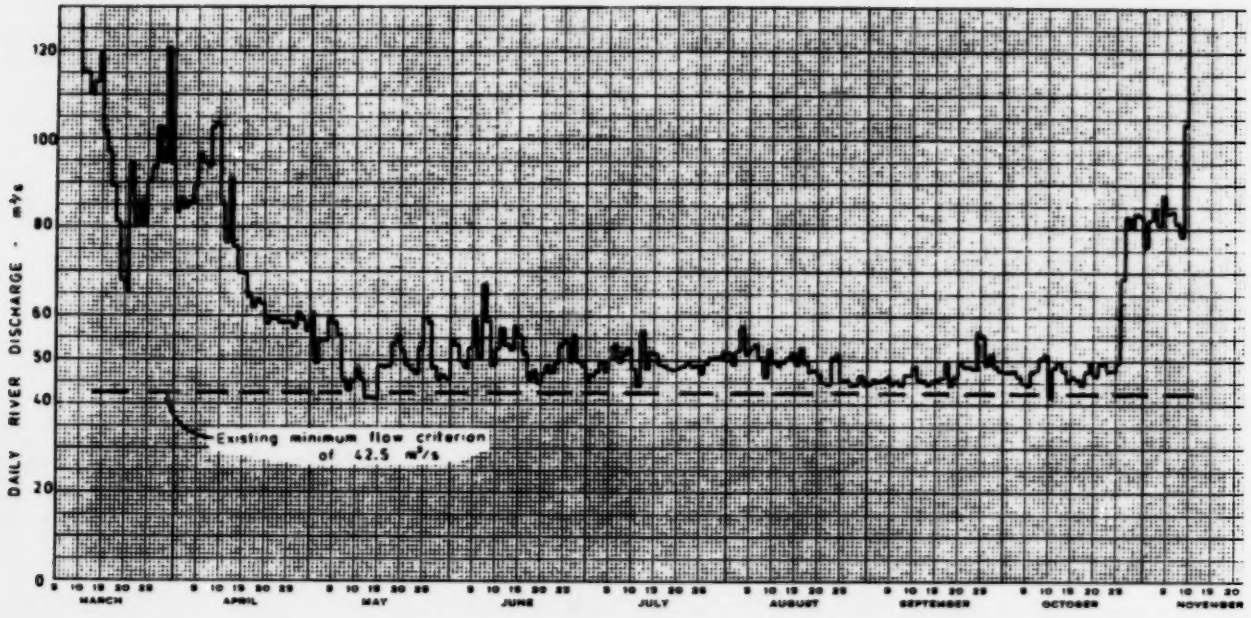

FIG. 6 - AVERAGE DAILY FLOWS IN 1977
SOUTH SASKATCHEWAN RIVER AT SASKATOON

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

Conclusions

After considering the present situation with respect to minimum flows on the South Saskatchewan River, the experience gained in the last 12 years with these flows, and some factors which may tend to change the situation in the future, it has been concluded that:

(1) There appears to be no pressing need to make a significant change in the present minimum average daily flow criterion.

(2) Those affected by the water levels of Lake Diefenbaker are fairly well satisfied with, or at least are tolerant of, its annual fluctuations.

(3) Varying the minimum flow on a seasonal basis was considered but rejected. If a number of groups of users would all benefit from greater flows during the same period of the year, such a variation might be justified, but there is no such consensus since:

(a) fisheries people would like to see much higher flows during the fish spawning of May and June,

(b) Meewasin Valley Authority and Saskatoon residents would like to have higher water levels in the river during the peak recreational months of July and August, and

(c) ferry operators would want higher river levels in the peak grain-hauling months of September and October.

(4) Present daily fluctuations in flow benefit SPC and Saskatoon residents, but disfavor ferry operators and those pumping from the river. No change is warranted.

(5) All downstream water users with physical works have adapted their works and operating procedures, to a greater or lesser extent, to the present summer flow patterns. Normally, low summer flows experienced during the last 12 years could be said to range from 45 to 75 m^3/s. Figure 6 shows daily flows at Saskatoon during 1977, the driest year in recent history: even in that year the flow rarely fell below 45 m^3/s. On those few days when flows did fall below 45 m^3/s, operating conditions for some river users became critical.

(6) Although no big change in the designated minimum flow can be justified, it is equally hard to find a reason not to increase the minimum by a small amount. A nominal increase would have no appreciable effect on SPC's operation, but would aid those operators who find river conditions critical during those few days when present minimum flows do occur.

Recommendation

Present operating procedures at Lake Diefenbaker call for minimum releases from Gardiner Dam which will cause a daily average flow of 42.5 m^3/s at Saskatoon. It is recommended that this be changed as follows:

> THE MINIMUM RELEASE FROM GARDINER DAM SHALL BE SUCH AS TO CAUSE THE AVERAGE DAILY FLOW OVER THE SASKATOON WEIR TO BE NOT LESS THAN 45.5 m^3/s.

Effect of Recommendation

During the 12 years since power was first produced at Gardiner Dam in December 1968, there have been relatively few days when the flow in the river was close to or reached the minimum. Figure 9 shows how the recommended change would make little difference to the general flow pattern of the river.

Under the present 42.5 m^3/s criterion, the actual flow in the river near Saskatoon ranges during the day between 35 and 51 m^3/s because of the daily fluctuation.* The recommended change would increase these flows by 3 m^3/s.

If this nominal increase is adopted, it will mean:

(a) No change will be noticeable by those affected by water levels of Lake Diefenbaker, or by those concerned with fish habitat or water quality,

(b) Ferry operators and those pumping from the river may notice that low water levels will have risen by about 0.02 m (about one inch): within Saskatoon, the rise would be one half as much, and

(c) SPC would experience a very minor increase in their power

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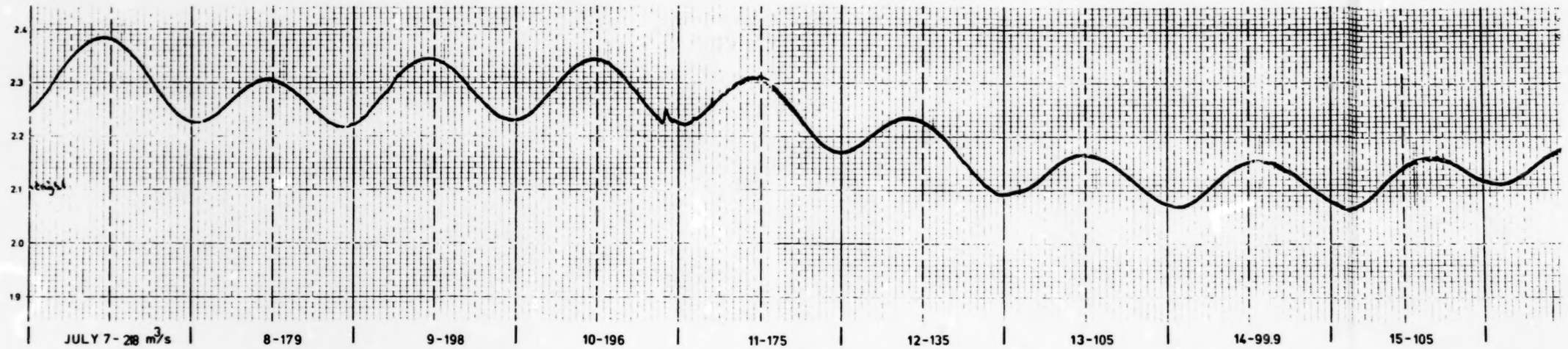
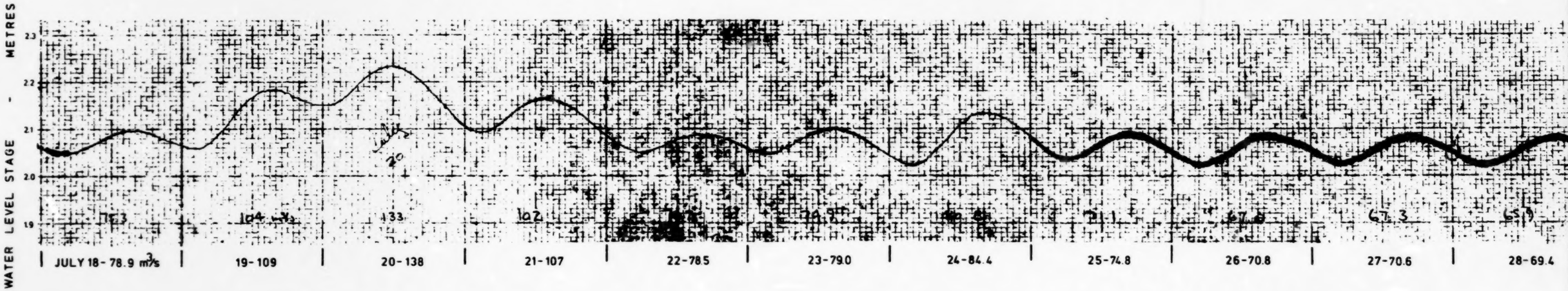
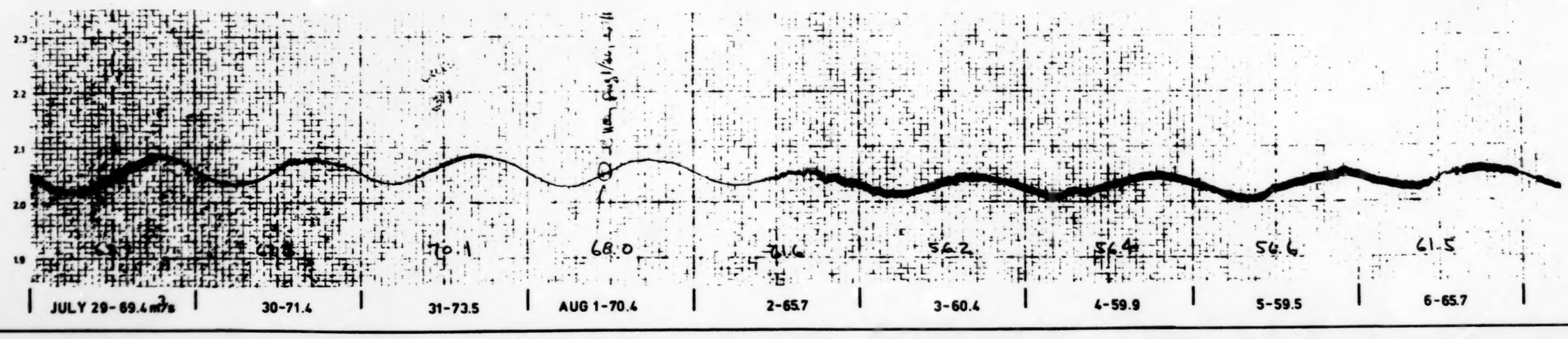
* Based on a daily variation of water levels at Saskatoon of 4.5 cm.

production costs. The small extra amount of water which would have to be released from Gardiner Dam to bring the minimum flow to 45.5 m^3/s (see Figure 9) would also be used to produce power at the turbines. What would be lost would be the incremental value between summer and winter power.







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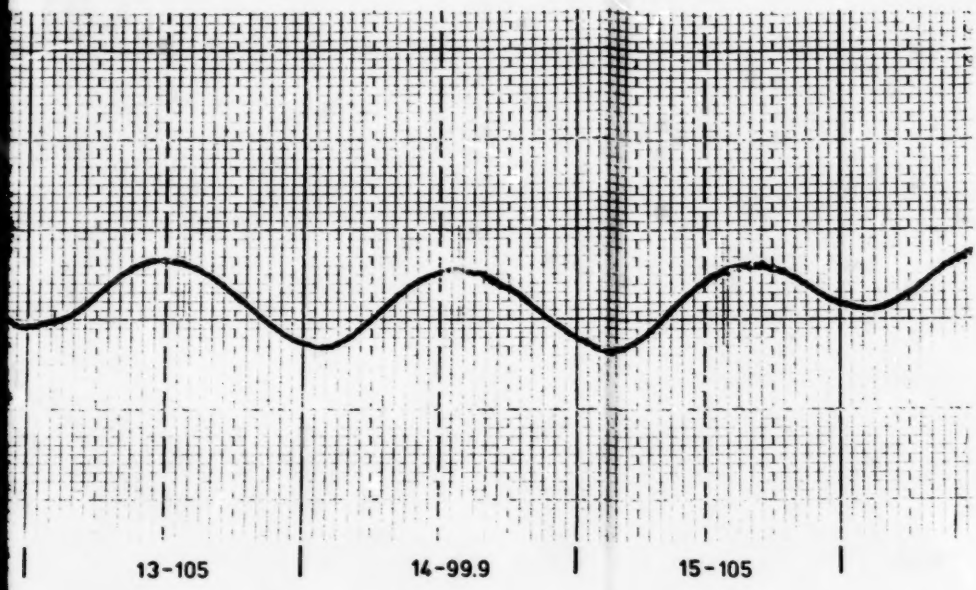
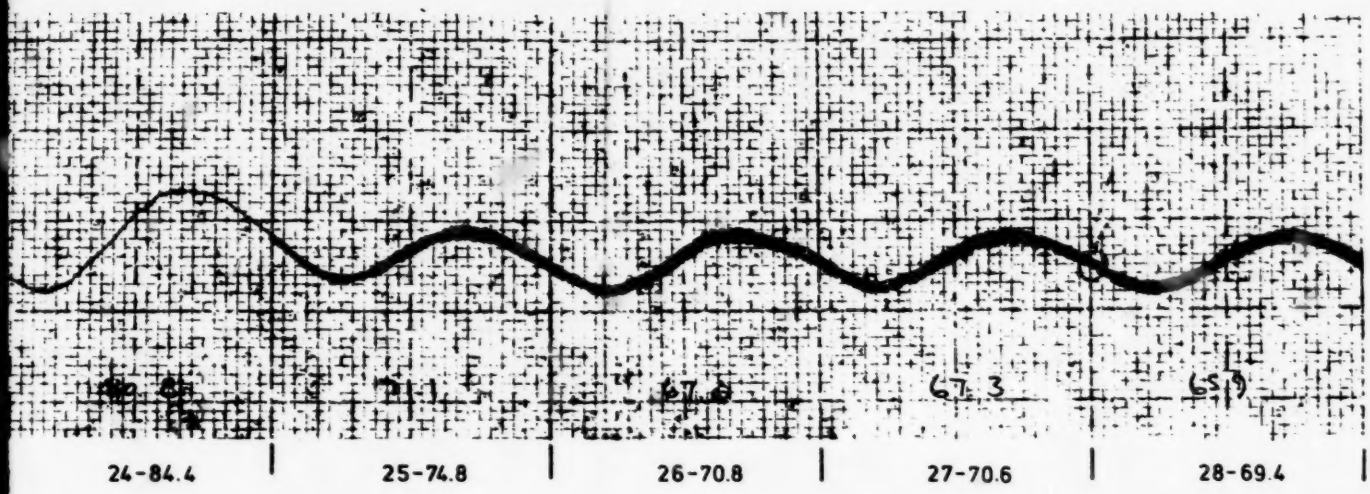
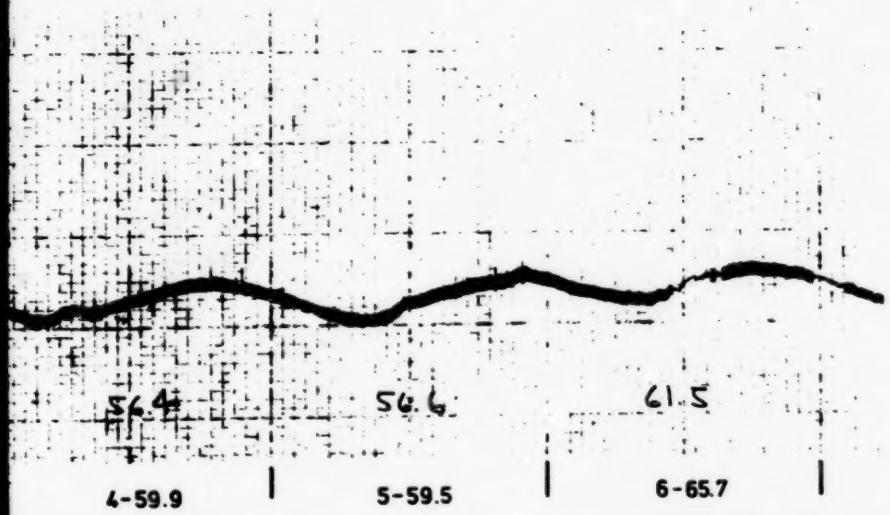
PALLISER WATER RESOURCE

WATER LEVEL FLUCTU
OF SOUTH SASKATCHEW
ABOVE SASKATOON WEI

MARCH 1980





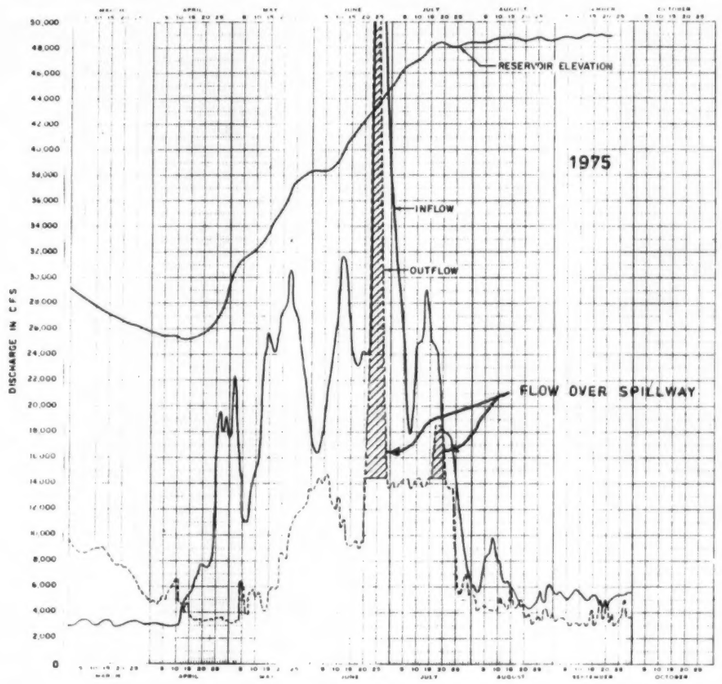


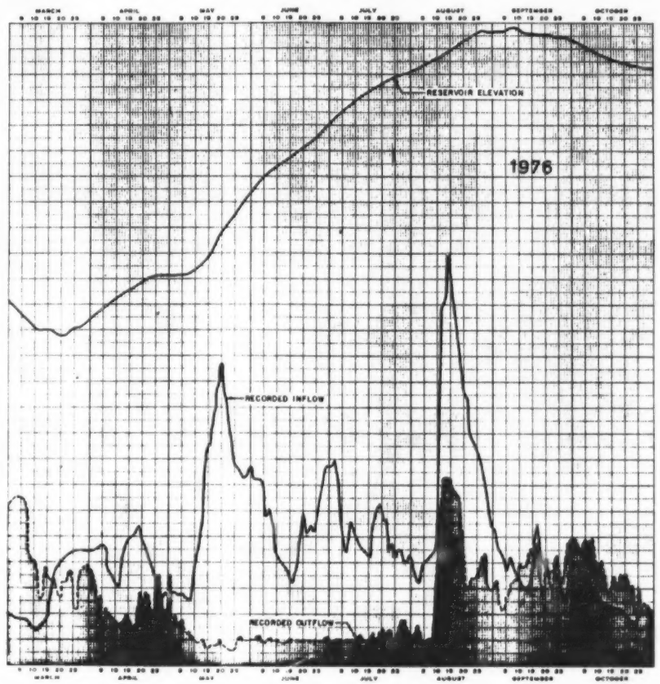
Copies of charts supplied by Water Survey of Canada, Canada Environment

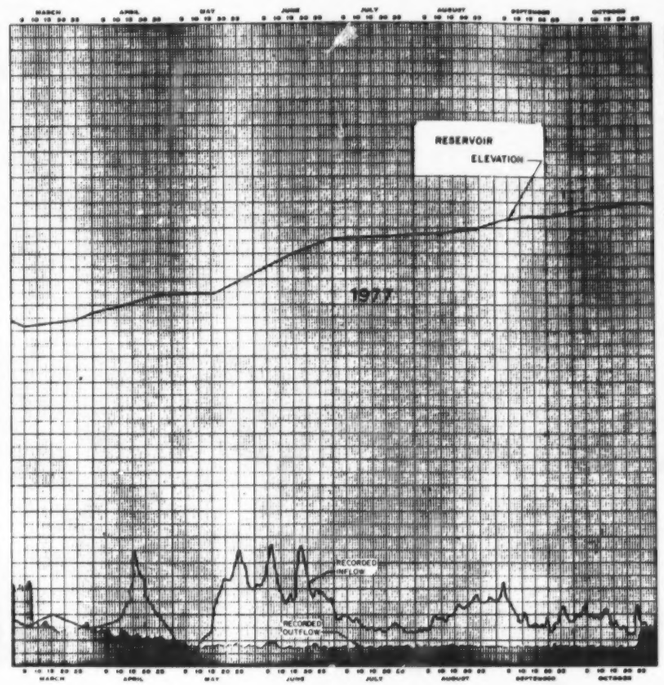
PALLISER WATER RESOURCE CONSULTANTS LTD.

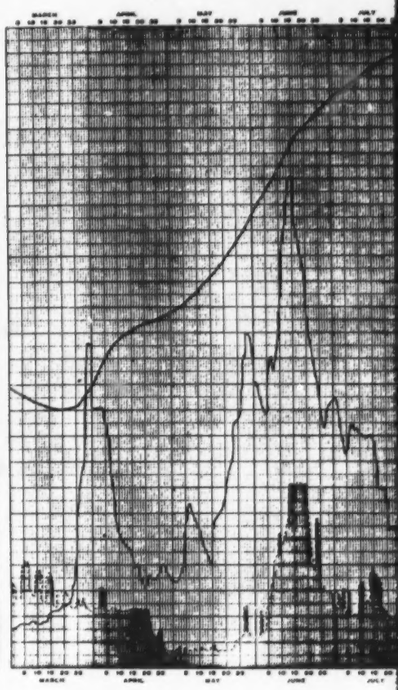
WATER LEVEL FLUCTUATIONS OF SOUTH SASKATCHEWAN RIVER ABOVE SASKATOON WEIR IN 1980

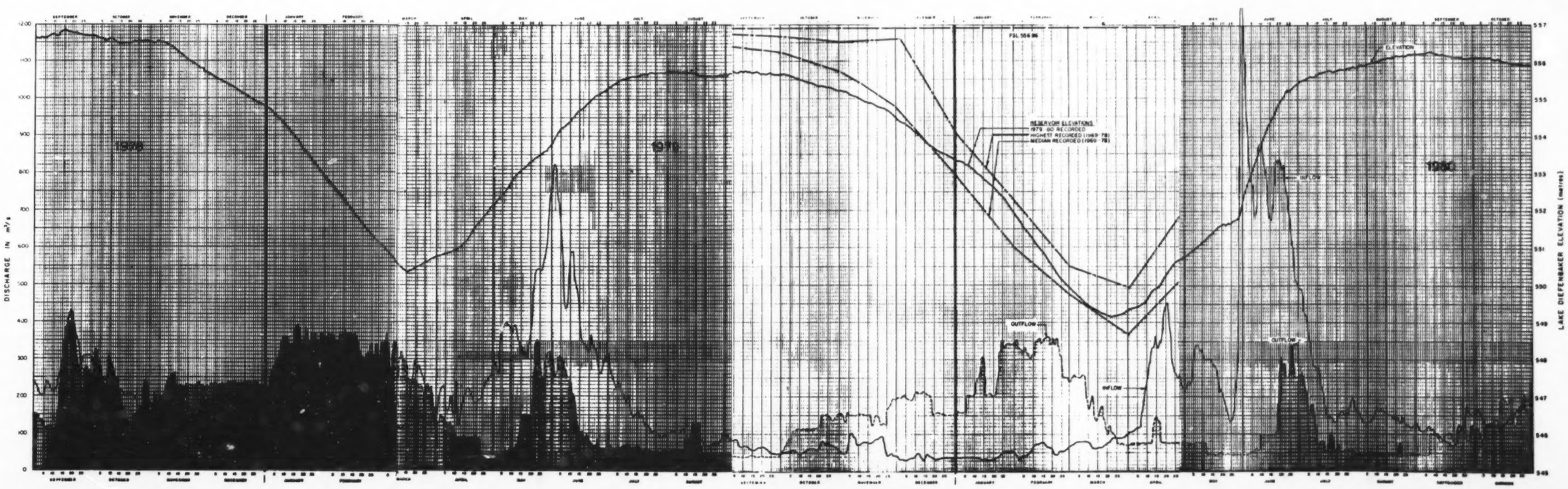
MARCH 1980 | FIGURE 7











NOTE:
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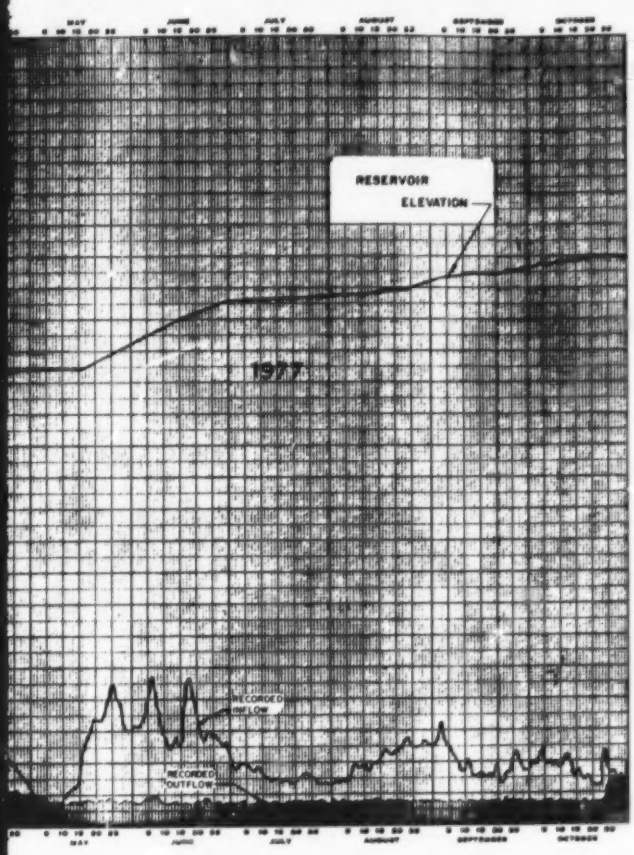
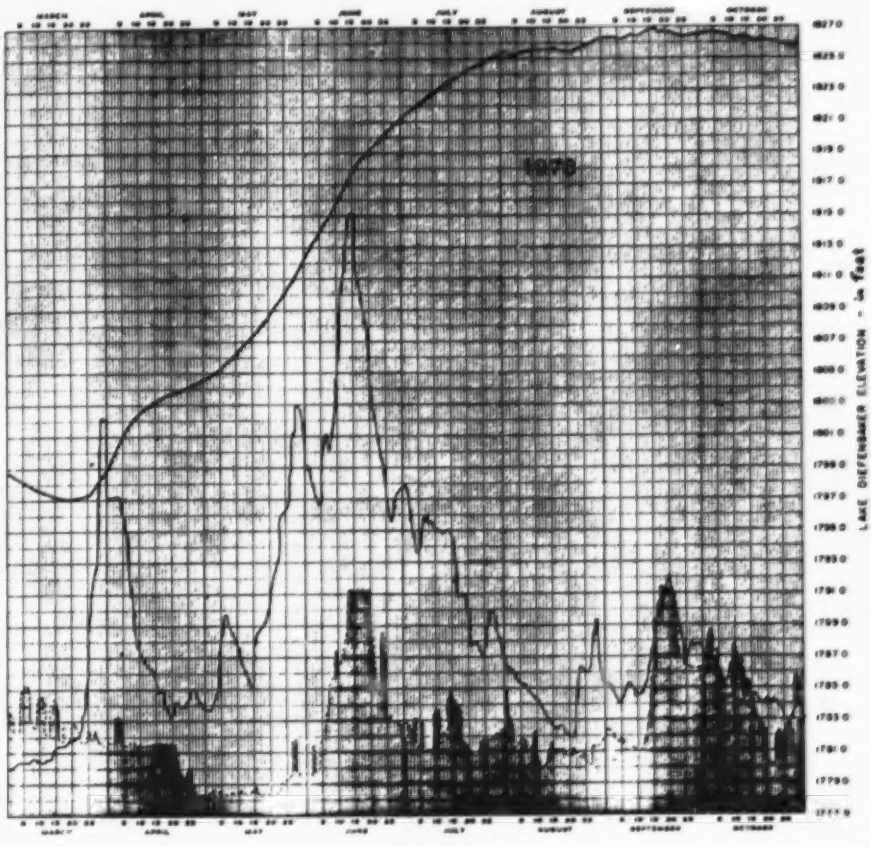
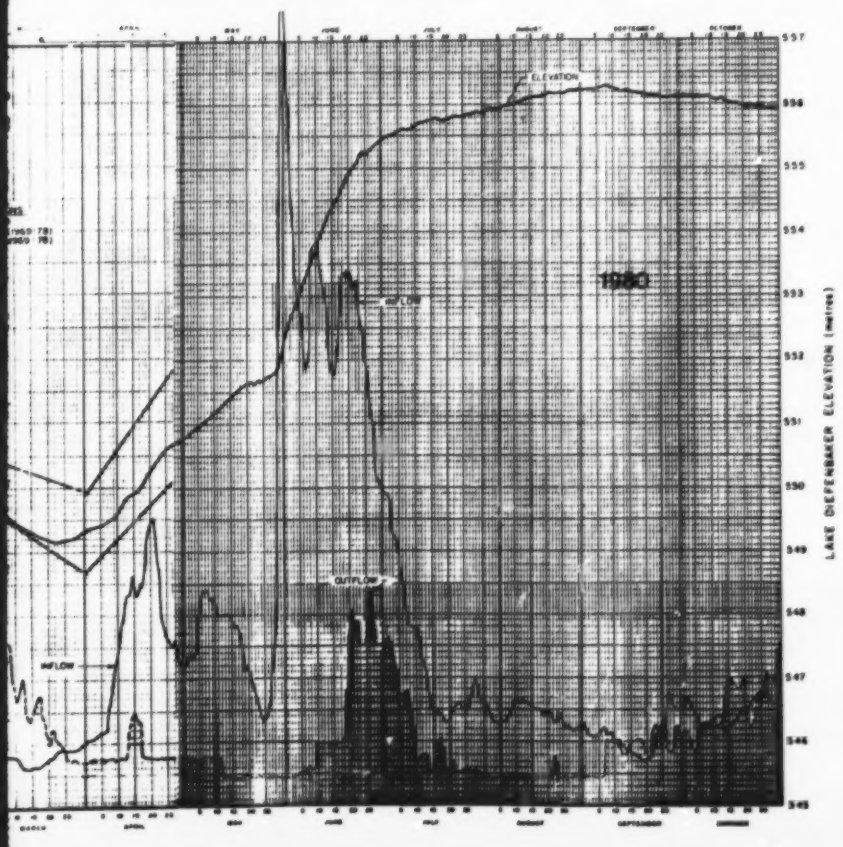
Date: March







LEGEND

Reservoir inflow

Reservoir outflow

Reservoir elevation

NOTE:

Full Supply Level of reservoir is 556.87 meters or 1827.0 feet

Designated minimum outflow (release) from the reservoir is 42.5 m^3/s or 1500 c.f.s.

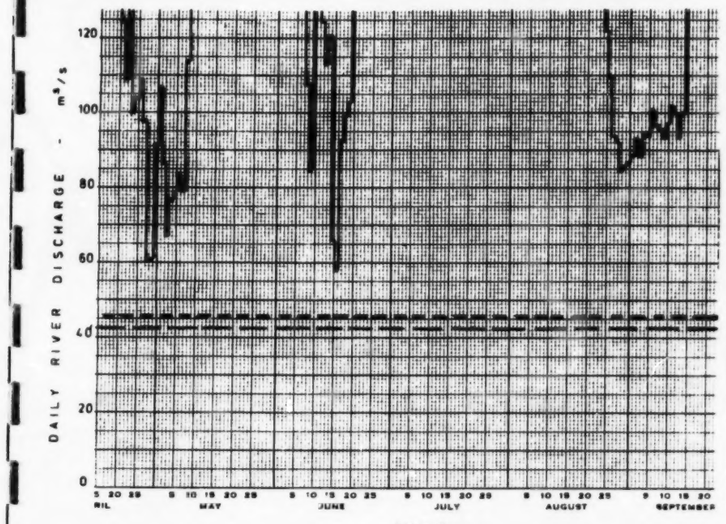
This drawing compiled from graphs prepared by Hydrology Branch, Environment Saskatchewan

PALLISER WATER RESOURCE CONSULTANTS LTD.

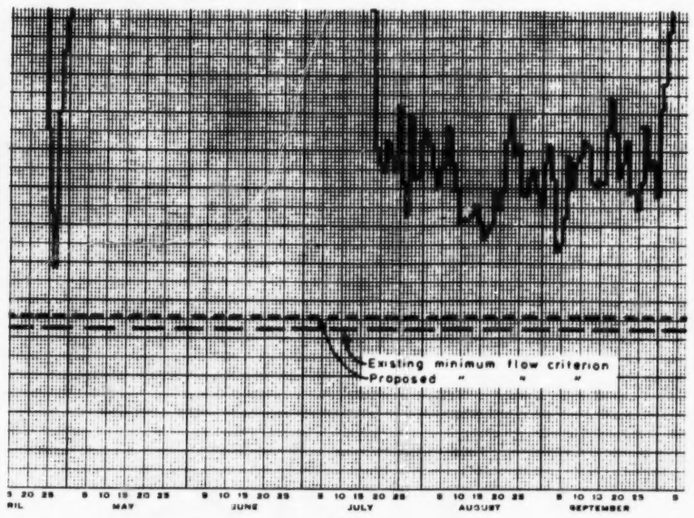
INFLOW TO, OUTFLOW FROM, AND WATER LEVELS OF LAKE DIEFENBAKER

Date: March 1980

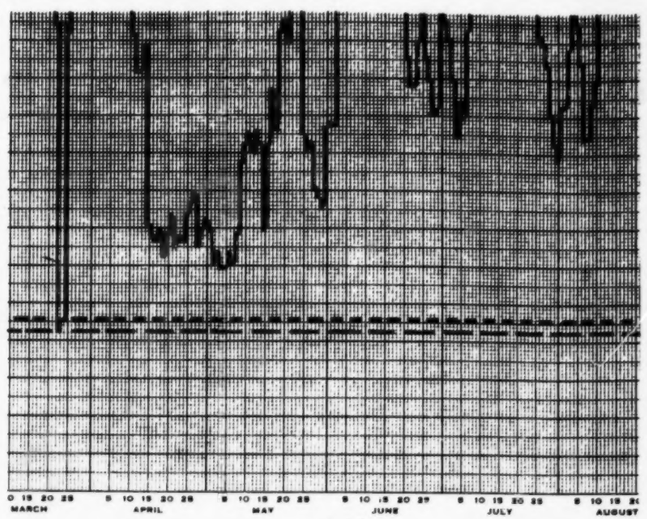
FIGURE 8



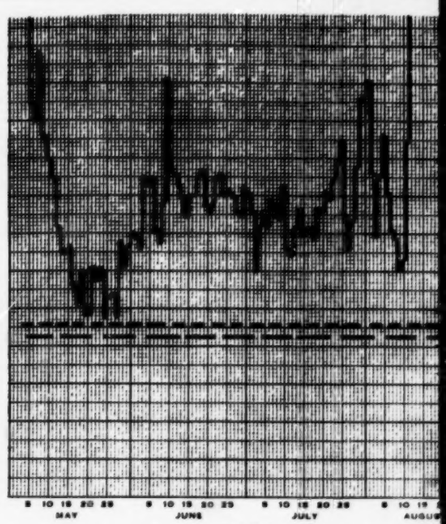
1970



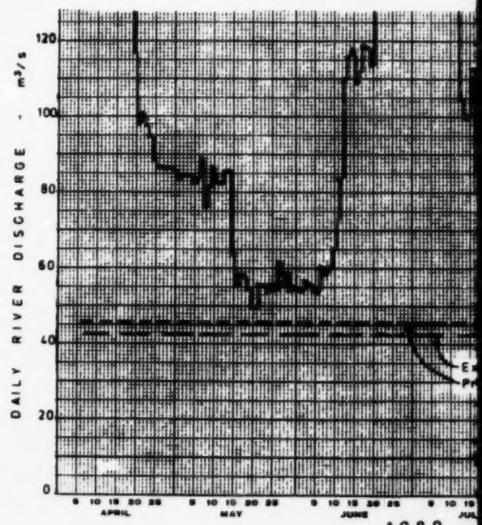
1971



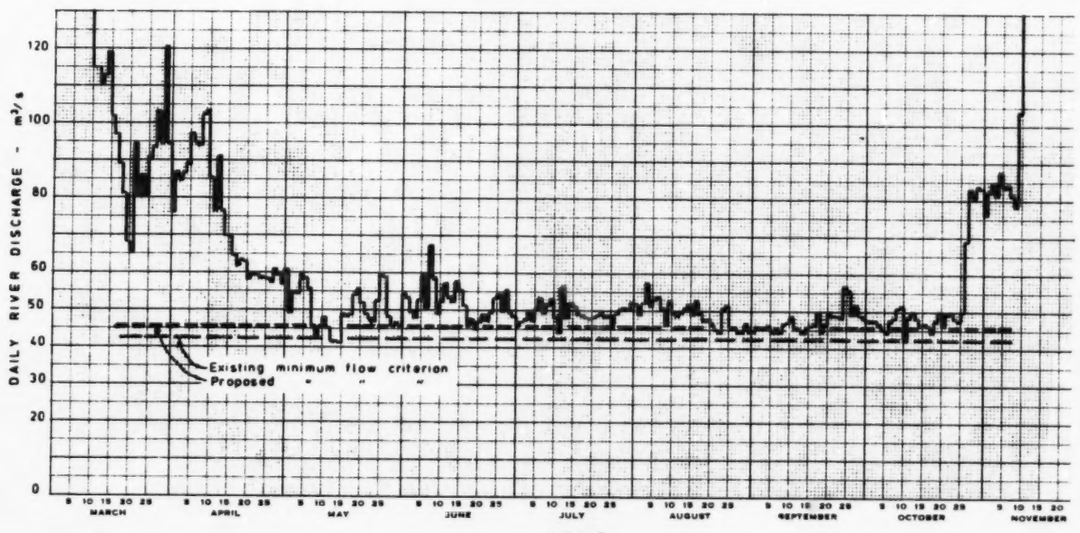
1973



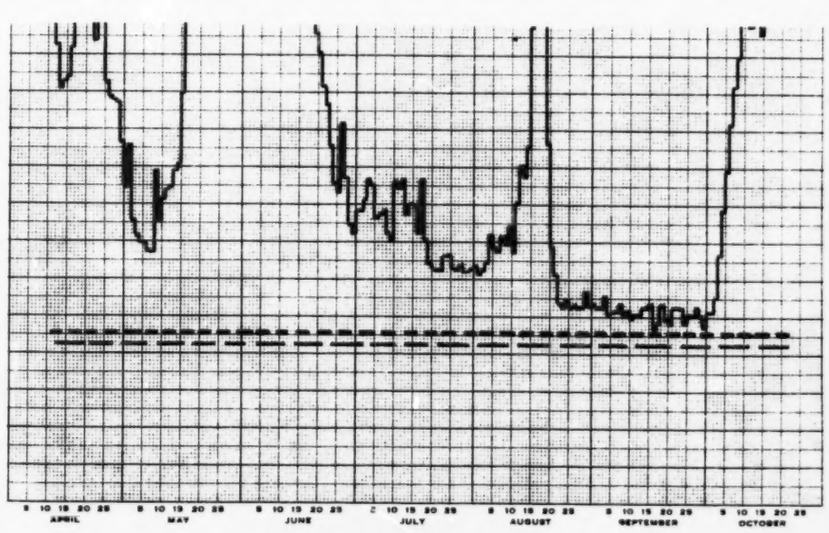
1976



1980



1977



1979

NOTE: The years 1969, 1972, 1974 & 1975 are not shown as no flows below 90 m³/s occurred in these years.

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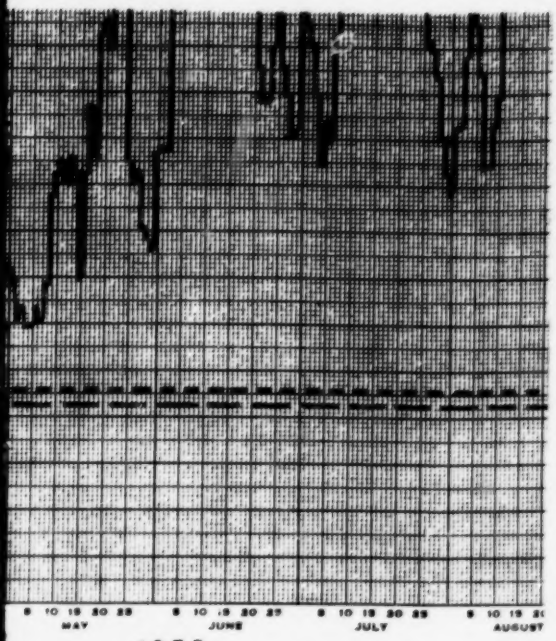

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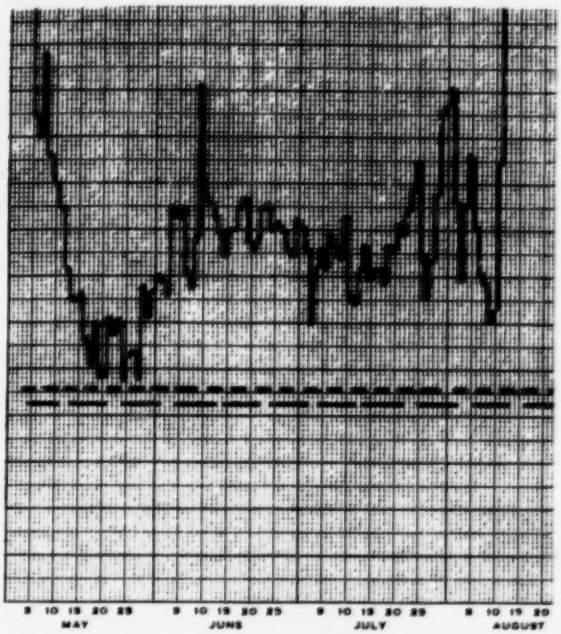

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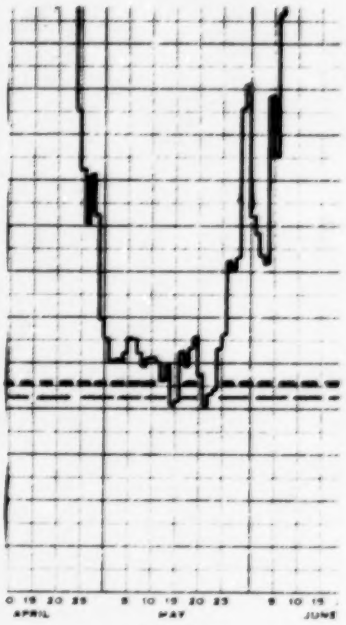
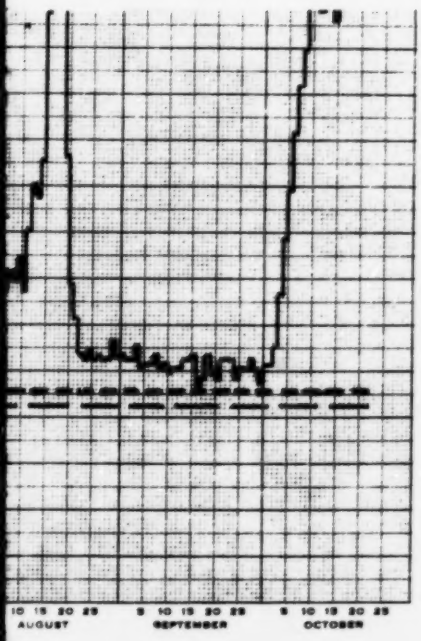
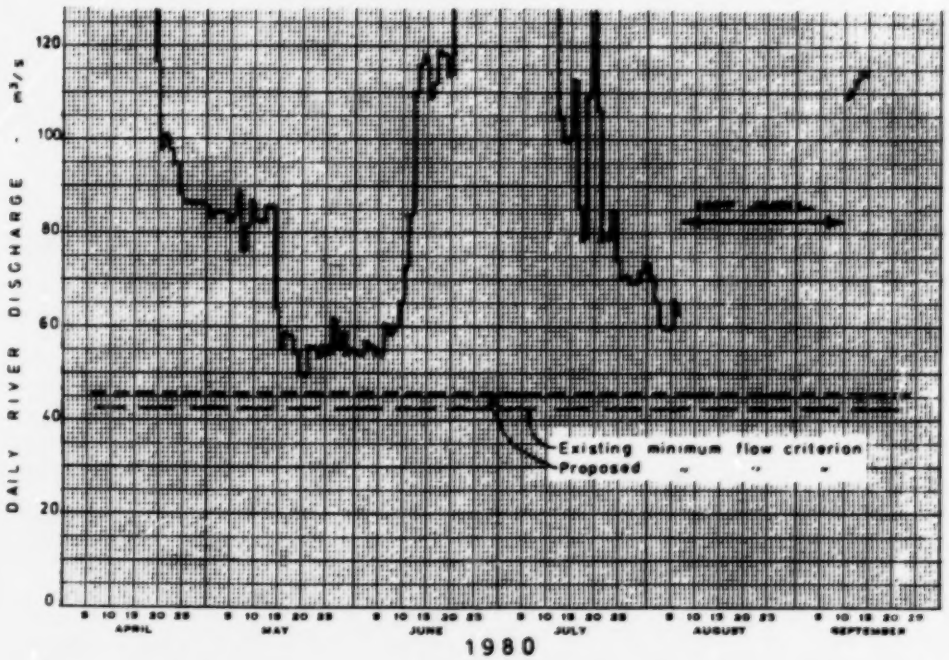


1978





1980

Data supplied by Water Survey of Canada.
Canada Environment.

NOTE: The years 1969, 1972, 1974 & 1975 are not shown as no flows below 90 m³/s occurred in these years.

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COMPLETE RECORD OF LOW FLOWS OF SOUTH SASKATCHEWAN RIVER AT SASKATOON DURING 12-YEAR PERIOD 1969 - 1980

MARCH 1981 | FIGURE 9

POOR

QUALITY

ORIGINAL